SIXTH EDITION. REVISED AND ENLARGED.

HUGHES'S EDUCATIONAL COURSE.

HOW TO DRAW A MAP:

CONTAINING FULL DIRECTIONS, BY SIMPLE AND EASY METHODS,

FOR PROJECTING THE PARALLELS OF LATITUDE,

Either Straight or Curved, and

THE MERIDIANS OF LONGITUDE;

TOGETHER WITH

MERCATOR'S PROJECTION, AND THE GLOBULAR PROJECTION OF THE WORLD,

With Hints on Drawing and Colouring, on the shading of Coast Lines, and the representation of Mountains, &c., &c., with complete Alphabets for Plain and Ornamental Lettering. Illustrated by numerous Plates and Diagrams, and *fac-simile* Maps, by

ALFONZO GARDINER,

Head Master of the Outcote-Bank Board School (Huddersfield School Board), Author of "Acoustics, Light and Heat," "Magnetism and Electricity," "Electricity," in "Extra Subject" Series, "The Standard Lesson Series," "John Heywood's Complete Series of Home Lesson Books," "Annotated Poetry for Standards V. and VI.," "John Heywood's Penny Parsing and Analysis Table." "John Heywood's Complete Standard Examination Guide," and joint author of "Plane and Solid Geometry," in Science Manuals, &c., &c.

London: HUGHES AND CO., Three Tuns Passage, Paternoster Square; JOHN MARSHALL AND CO., Paternoster Row; JOHN HEYWOOD, Manchester; and all Booksellers.

1879.

[ENTERED AT STATIONERS' HALL.]

[Price 1s.

HOW TO DRAW A MAP,

By A. GARDINER.

1.—The knowledge of geography is far more an education of the eye than is generally supposed. No geographical knowledge is thorough which does not enable a student to picture, in his mind's eye, the general shape of a country, its chief physical features, and the *position* of all the important places.

2.—The best way to obtain this accurate acquaintance with a country is by a thorough study of good maps, and by frequent map-drawing.

3.—As a commencement, outline maps should be drawn on scrap paper, or slate, until the general shape is firmly fixed on the memory. Mountains may then be inserted, next the rivers, after that the political divisions and towns.

4.—In drawing a map to illustrate the facts mentioned in any particular text book of geography, care should be taken to insert only *important* names and particulars, or those mentioned in the book. A common fault with map-drawers is to insert too many names; and the same fault may be found with most of the atlases in common use.

5. Map Projection.—No map can be considered as complete unless the degrees of LATITUDE and LONGITUDE are inserted.[1] To do this *accurately* has exercised the ingenuity of geometers and mathematicians since the days of An-ăx'-i-man'-der, of MI-lē'-tus (who is said to have been the inventor of geographical charts, about 570 B.C.), up to the present day.[2] The reason of this is that it is impossible to spread out a *spherical* surface so as to lie *flat* without tearing or folding over some portion of it.

Before the student can set about drawing a map scientifically, he must prepare his *projection*, that is, plan out the degrees of Latitude and Longitude over which the tract of country he is going to represent extends. To do this properly requires an elementary knowledge of plain geometrical drawing. A few of the necessary problems are explained in the following pages, but any one knowing how to use his T square, set square, and other drawing instruments readily, will be able to expedite his work much.

6.—The method now chiefly used is called the *conical projection*, and supposes the spherical surface of the earth to be surrounded by a cone, which touches the sphere at the parallel intended to represent the middle of the map, and the vertex of which is situated somewhere beyond the polar axis produced. (See paragraph 27). The various points of the sphere having been projected on to the surface of the cone, it is then supposed to be rolled out flat.[3]

7.—The method of projection here explained is a modification of the conical projection; and though not absolutely accurate, as, in fact, no method can be, is sufficiently so for all ordinary purposes. It has the further advantage of only requiring ruler and compasses, dispensing with all abstruse calculations.

8.—On examining a globe it will be seen that the **lines of latitude,**[4] or as they are generally called, **the parallels** are all at an *equal* distance from each other, and all parallel to the equator. Except when a very large area is to be represented in a map, these lines may be drawn as straight lines. Three or four are always sufficient for any map. Suppose Australia (Plate I.) is to be drawn; on examining an atlas it will be seen that the parallels of 10°, 20°, 30°, and 40° South will include a

1 "The neatness as well as the correctness of these outlines will be taken into consideration. The degrees of longitude and latitude must be given to obtain *full* credit for the exercise."—*(Syllabus for Certificate Examination of the Education Department).*

2 "The first tolerably accurate map of England was drawn by George Lilly, who died in 1559."

3 The principles on which a map of the world is drawn are simply explained in "Groves' Primer of Geography."—*Macmillan.*

4 Latitude (L. *latitudo*, breadth, *latus*, broad, through the French *latitude*) is the distance of any place, in a direct line, north or south from the equator, measured in degrees (°), minutes (′), and seconds (″)—if in the northern hemisphere, it is said to be in north latitude, and if in the southern in south latitude. Parts situated in *high latitude* are near the poles; in *low latitude*, near the equator; and in *middle latitude*, in the temperate zone

hat is required North and South; and that the **lines of longitude,**[5] or **meridians**[6] of 115°, 125°, 135°, 145°, and 155° West will be sufficient guides towards the East and West.

9.—To obtain the Parallels.—Commence by drawing a centre meridian (which of course will be vertical) as near as possible in the middle of the map—in this case the longitude of 135° E. Draw line *a, c, b*—the parallel of 10° S.—at right angles to the centre meridian; from *c* set off the equal distances (according to the size of map required), *c d, d e, e f*, and hrough the points draw the parallels of 20°, 30°, and 40° South.

10.—To obtain the Meridians.—On again examining a globe it will be seen that, whilst the distance between any wo parallels is everywhere the same, the distance between the meridians gradually decreases, from the equator, to nothing at he poles, where they all meet. On the equator the distance measured between any two meridians is the same length as the istance measured between any two parallels. The decrease of the distance between the meridians, from the equator to the oles, is gradual, and bears on every parallel a certain proportion to the length at the equator. To find this length proceed as ollows :—

11.—Let A B (fig. 1) represent the distance included between any *two* meridians on the quator (or of any number of meridians—in this case 10 (because we are drawing the parallels t 10° apart); or what is the same thing, the distance between any two of the parallels already lrawn, as between *cd*, *de*, or *ef* (Plate I). Draw A C at right angles to A B,* and with ompasses from A, with distance A B, draw the arc B C. A C is therefore equal to A B, nd A B C is a quadrant, A representing the centre of the earth, B the equator, C the pole, nd the distance C B, the outer surface of the earth, includes 90°, from B to C. Divide the istance B C into nine equal parts, and number them from 10° to 90°, as in the figure.†

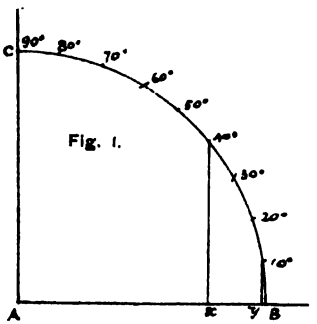


Fig. 1.

12.—As our extreme parallels are 10° and 40° S., it will be sufficient to find the distance etween the meridians (which are, like the parallels, to be 10° apart) on *these two* parallels, nd to draw straight lines through the points found. From 10° and 40° (Fig. 1) draw 10° *y* nd 40° *x*, each perpendicular to A B, or parallel to C A.§ A *y* is the distance to be marked ff on the tenth parallel on each side of the centre meridian, viz. : *c g, g h*, and *c k, k l* Plate I.), for the points through which the meridians have to pass; and A *x* is the distance o be measured off on the 40th parallel, viz. : *f m, m n*, and *f p, p q*. Join *g m, h n, k p*, nd *l q*. These are the required meridians. Draw the boundary lines, and the projection s complete.

If it be required to put in the *Tropic of Capricorn*, which is situated at a distance of 23° 30′ south of the equator (accurately 23° 28′ S), the distance *d e* must be divided into 10 equal parts,‖ and 8½ of these parts set off from *d* southward, through which the line must be drawn parallel to the other parallels.

The *Tropic of Cancer* is 23° 30′ N, the *Arctic Circle* 23° 30′ from the North Pole, and the *Antarctic Circle* 23° 30′ from the South Pole.

---

5 Longitude (L. *longitudo*, length of time or space—*longus*, long, through the French *longitude*) is distance east or west of any place on the arth's surface from a fixed point—in England that point is the Royal Observatory at Greenwich, near London; that of France is at Paris; of America t Washington. The terms *longitude* and *latitude* had their origin from the notion of the ancients that the earth was longer from east to west (longitude) ıan from north to south (latitude), these terms expressing *length* and *breadth*.

6 Meridians (L. *meridies*, mid-day—*medius*, middle, *dies* day, through the French "méridien") are so called because all points on the earth's surface ırough which one of these lines pass has mid-day, or noon, at the same instant of time.

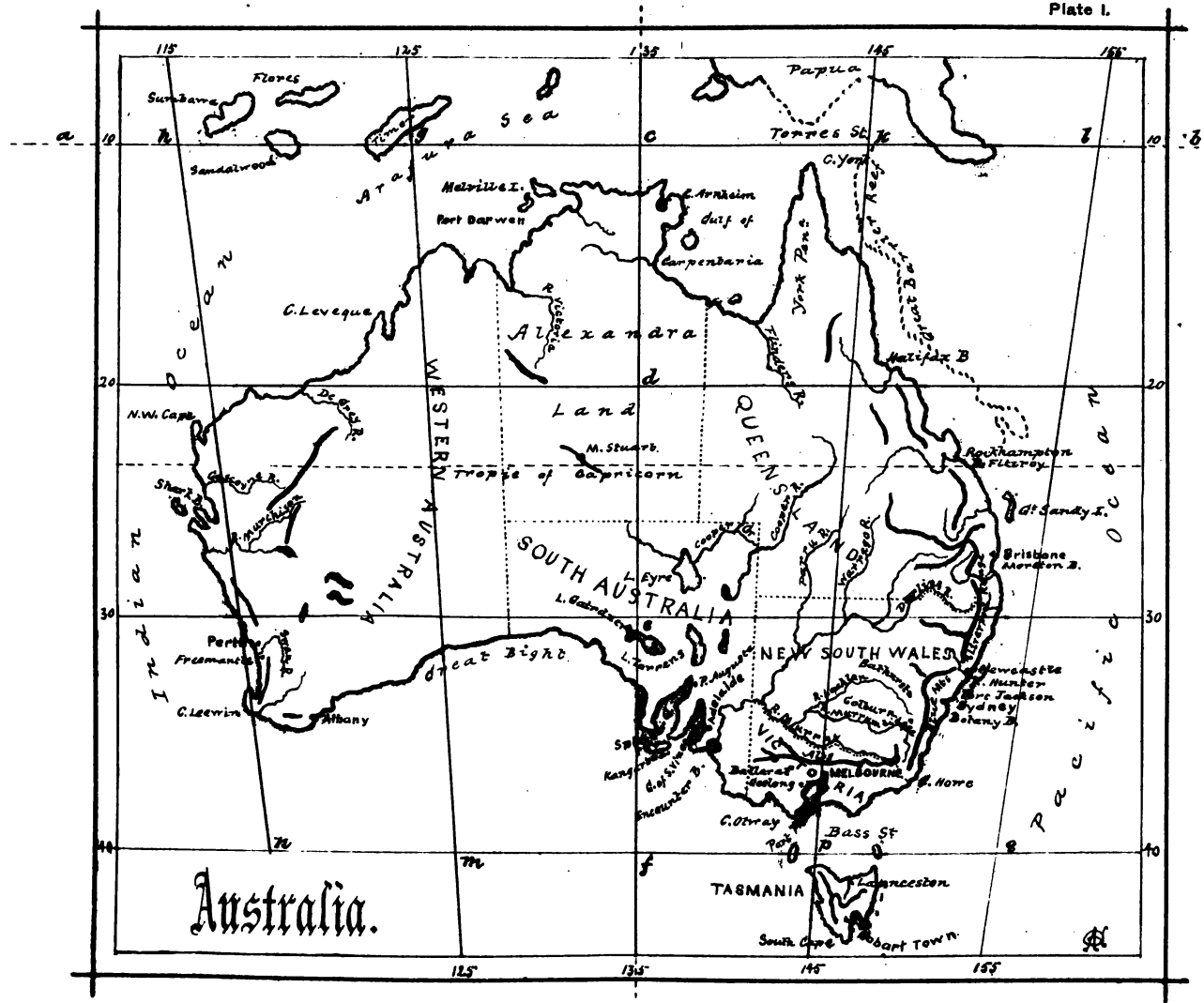
* See problem How to Draw a line at right angles to another line, page 6.

† ,, ,, Divide the circumference of a quadrant, page 6.

§ ,, ,, Draw a straight line parallel to another straight line, page 6

‖ See problem, pages 12 and 18.

Plate I.



13.—The same plan has to be followed in every case. First draw a centre meridian, when possible. Then, according to the size the map is required to be, and the extent of the earth's surface which it is desired to represent, set off equal distances on it for the points through which the parallels are to pass, and draw them. Except when very great accuracy is required it is not advisable to draw many parallels and meridians, but just sufficient to ensure a correct outline. Next find, by an exactly similar plan, as in Fig. 1, the points through which the meridians are to pass on the extreme parallels—*i.e.*, on the one furthest north, and the one furthest south, and join the points found. A B (Fig. 1) is *always* the same length as the distance the parallels have been drawn apart, and B C is *always* divided into 90 equal parts. It is best to do all this in pencil first, and then put the boundary lines and the projection in ink.

In New Zealand (Plate III., page 7), the extreme parallels are 35° and 45° S. Fig. 1, Plate IX., page 16, gives the distances the meridians will be apart on these parallels. In this case it will be observed that it is not necessary to divide B C into all the 90 parts. First find 30° and 45° (by Fig. 2, Plate II., page 6), divide the distance between these degrees into 3 equal parts, and draw 35 *y* and 45 *x* as shown.
Fig. 2, Plate IX., shows how to find the required points for Spain and Portugal (Plate VIII., page 15), where the extreme parallels are 44° and 36°

14.—When no meridian, exactly in the centre of the map, can be used, the following plan must be adopted :—Draw a central line, in pencil, and the parallels as before. To find the points through which to draw the two meridians nearest the centre of the map, set off, on each side of the central line, only *half the distance found for that parallel.* The points for other parallels, east and west of these two, must of course be the full distance. For instance, in the map of New Zealand first draw *a b* in pencil; set off, to *c* and *d* on each side of *a*, half the distance A *y* (Plate IX., fig. 1), and from *b* set off, to *e* and *f*, half the distance A *x*.

15.—Drawing.—After the projection is completed, the outline must be drawn lightly and accurately in pencil, together with a faint line for the general direction of the mountains, and the course of the rivers.

16.—Colouring.—If political divisions are to be indicated by colours, they must be done before anything is inked in otherwise the ink will "run," especially if Indian ink is used. Mix the colour *thin*, use a moderate-sized brush, and if a *large* surface has to be coloured, either damp the *under* side of the paper with clean water, or *breathe strongly* on the side to be coloured. This will cause the colour to spread evenly. Let each colour dry before the next is put on, otherwise one will run into the other where their edges join.

17.—Coast Line.—The best way is to draw it in blue ink,[7] with a moderately thick-pointed pen, as in Plate III. Do not make it too *fine*, nor too *stiff*, but rather "wavy," so as to indicate small indentations. If liked, a *black* line may be used, as in Plate I. After the ink is dry a blue wash may be run round, as in Plate I., or it may be "*shaded*" with a *blue* pencil, or crayon, as in Plate VIII., or with *parallel lines*, as in Plate III. In this case let all the lines be made at an equal distance from each other, not too thick nor too long, and perfectly parallel with the top and bottom of the map. Do not line and shade the coast as in Plate IX., Figs. 3 and 4, as it is exceedingly difficult to do nicely, and does not look well except a large amount of time is spent over it, which cannot be spared, especially in an examination. Another way of shading the coast is shown in Plate IX., Fig. 5, but it is not recommended. Plate I. is a good example of how a map may be done in an examination; and if the shading be done with blue pencil, it is very effective. Be careful to make the shading of an even tint, and keep the marks of the pencil parallel with the top and bottom of the map. Names of divisions may be put in *red* ink.

18.—Rivers and Lakes.—Always begin at the source of a river with a *fine line*, making it wavy, and, as it reaches the coast, increasing in thickness. Take especial care that the rivers do not look like "wires," as in Plate IX., Fig. 6. Only put in the *chief* tributaries, the smaller streams crowd the map unnecessarily. Proceed with the **lakes** in the same way as with the coast, and shade after a similar manner.

19.—Mountains.—These are the most difficult parts of a map to draw *quickly*, and to look well. The *neatest* plan is to shade them in Indian ink, as in Plate VIII. To do this well requires considerable practice, but it quite repays the trouble

[7] Ordinary blue ink is generally of a dirty colour. The best thing to use is water colour, mixed with a very small portion of gum. French Ultra marine, or Cobalt, are very useful colours, and may be used, when thinned with water, to wash round the coast. Aniline blue ink is, however, very good for the purpose.

of learning, and is then soon done. Begin, using a moderate-sized brush, with a very faint tint, and, as it dries, go over and over again, gradually working up to the darkest shades, trying to get the effect produced by a well engraved map at a little distance from the eye.[8] Other ways of indicating mountains are shown in Plates I. and III., but be careful not to follow the example in Plate IX., Fig 6. The greatest objection to the mountains in Plate I. is that they give the map a *dirty* look. This may be obviated in a great measure by using a strong wash of "burnt sienna." Whether black, or in paint, the lines should be made thicker to indicate the relative heights of the mountains. Summits can be indicated by circles thus ○ or thus ●. If liked, the two styles in Plates I. and III. may be united, as in Fig. 7, Plate IX.

20.—Towns may be indicated either by small circles thus ○ or dots thus • Capitals thus ■ or thus □

21.—Lettering.—The following kinds of letters may be used as indicated :—(*a*) or (*b*) for the names of political divisions, &c.; *(c)* for oceans, *(d)* or *(f)* for the names of very important towns, islands, &c.; *(e)* for physical features. Other towns may be indicated thus *(e)*. The complete alphabets are given below. The name of the map may be indicated in the style *(g)*, or *(h)*, or any other ornamental or plain letter liked.

22.—As far as possible let the names, particularly round the coast, be parallel to the top of the map. This cannot always be done, especially in naming rivers and mountains and political divisions. Do not crowd the map with names; the maps given as examples are almost full enough; do not make the letters too black, and keep them at equal distances. In naming towns do not spread them out too far. "*Northallerton*" will look much better than "*N o r t h a l l e r t o n .*" Upright letters are the easiest to read, and if the hand be held as for "back-hand writing," small letters can be made quickly and well. The simplest kind of letters, such as the styles *(a)*, *(b)*, *(d)*, or *(f)*, are the best to make, and look the best.

(a) ABCDEFGHIJKLMNOPQRSTUVWXYZ

(b) *A B C D E F G H I J K L M N O P Q R S T U V W X Y Z*

(c) *ABCDEFGHIJKLMNOPQRSTUVWXYZ*
a b c d e f g h i j k l m n o p q r s t u v w x y z

(d) ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz

(e) *ABCDEFGHIJKLMNOPQRSTUVWXYZ*
abcdefghijklmnopqrstuvwxyz

(f) *ABCDEFGHIJKLMNOPQRSTUVWXYZ*
abcdefghijklmnopqrstuvwxyz

(g) 𝔄𝔅ℭ𝔇𝔈𝔉𝔊ℌ𝔍𝔎𝔏𝔐𝔑𝔒𝔓𝔔ℜ𝔖𝔗𝔘𝔙𝔚𝔛𝔜ℨ
𝔞𝔟𝔠𝔡𝔢𝔣𝔤𝔥𝔦𝔧𝔨𝔩𝔪𝔫𝔬𝔭𝔮𝔯𝔰𝔱𝔲𝔳𝔴𝔵𝔶𝔷

(h) 𝒜ℬ𝒞𝒟ℰℱ𝒢ℋℐ𝒥𝒦ℒℳ𝒩𝒪𝒫𝒬ℛ𝒮𝒯𝒰𝒱𝒲𝒳𝒴𝒵
𝒶𝒷𝒸𝒹ℯ𝒻ℊ𝒽𝒾𝒿𝓀𝓁𝓂𝓃ℴ𝓅𝓆𝓇𝓈𝓉𝓊𝓋𝓌𝓍𝓎𝓏

8 Instead of Indian ink either a black crayon, or better still, one of Cohen's No. 52. Parcel Pencil, may be used. A little practice will soon enable the student to get a good effect, as in Plate VIII. This plan is better than using Indian ink in an examination.

23.—When practising map drawing the following table may be of assistance in economising time, and if committed to memory will always be ready for examination purposes. It gives, in easily measured fractions, the proportionate distances between a few of the meridians. For example, on the parellel of 60°, the distance between any two meridians is just half what it is at the equator, or in other words it is one-half the distance between the parallels; at 48° it is $\frac{2}{3}$, at 70° $\frac{1}{3}$, &c. This table might be calculated for all the parallels from 1° to 90°, but none of the other fractions could be easily measured.

24.—Thus, in drawing a map of England, use the parallels of 51°, 53°, and 55° N. Draw the lines for these at, say, two inches apart; take the meridian of 2° W. for the central meridian, and on each side of it set off, on the 53° parallel 3-5ths of two inches, *i.e.* 1 and 1-5th inch for points through which to draw the meridians of 0°, 2° E., and 4°, 6° W. The nearest number in the table to 51°, the lowest parallel in the map, is 48°. Draw the parallel of 48° N., and on each side of meridian 2° W. set off $\frac{2}{3}$ of two inches, *i.e.* $1\frac{1}{3}$ inch for the other points, and complete as before.

25.—Table of proportionate parts.—

On the Equator 1	At 37° = $\frac{4}{5}$	At 60° = $\frac{1}{2}$	At 72° = $\frac{3}{10}$
At 10° = 1 nearly	,, 42° = $\frac{3}{4}$	,, 65° = $\frac{5}{12}$	,, 80° = $\frac{1}{6}$
,, 24° = $\frac{9}{10}$	,, 48° = $\frac{2}{3}$	,, 66° = $\frac{2}{5}$	,, 90° = 0
,, 33° = $\frac{5}{6}$	,, 53° = $\frac{3}{5}$	,, 70° = $\frac{1}{3}$	

If a good plane scale be used, which will contain on one side an inch divided into various parts, and on the other a diagonal scale of an inch, all the above fractions may be readily measured off if the distance between the parallels be first taken from one of the divisions on the scale. Either of the plans shown in Plate VI., Figs. 2 and 3, may be used for dividing the distance into the required number of parts, or they may be done by trial with compasses, or even guessed by the eye.

GEOMETRICAL PROBLEMS.

To Draw a Link at Right Angles to another Given Line.—Let A B (Fig. 1, Plate II.) be the given line. From A with any radius describe arc *d e f*. From *d* with same radius cut arc in *e*, and from *e* in *f*. From *e* and *f* with any radius describe arcs cutting in C. Join C A. The line C A is at right angles to A B.

To Divide the Circumference of a Quadrant.—From the points B and C (Fig. 2, Plate II.) with the distance A B, cut the arc in the points *a* and *b*. This divides the arc into three equal parts—*a* is therefore 30° and *b* 60°. Divide B *a*, *a b*, and *b* C each into *three* equal parts by trial with compasses—each of these divisions is 10°. From C and B with any radius describe arcs cutting in *e*, join *e* A—where the line cuts the arc is 45°. From C and *b* with any radius, and also from B and *a*, describe arcs cutting respectively in *f* and *d*, join to A, and the arc C B is cut for 75° and 15°. Any other divisions must be measured by trial with compasses.

To Draw a Straight Line Parallel to another Straight Line.—Let it be required to draw from the point *a* (Fig. 3, Plate II.) a line parallel with C A. In C A take any two points—*d* and *x*—not opposite to *a*. With distance *d x*, from centre *a* describe arc *f*, and from *d* with distance *x a* cut arc *f* in point *e*. Join *e a*, and produce it as far as required: *e a* is parallel to C A.

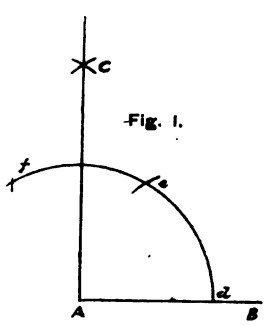


Fig. 1.

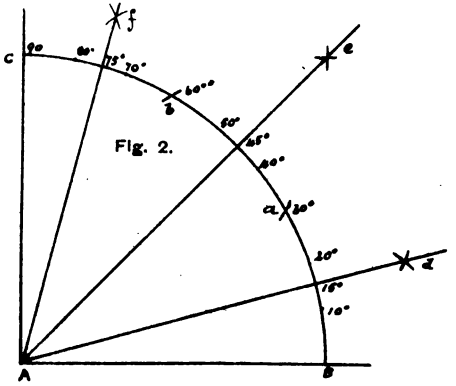


Fig. 2.

Plate II.

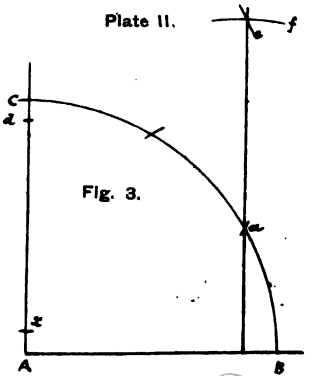
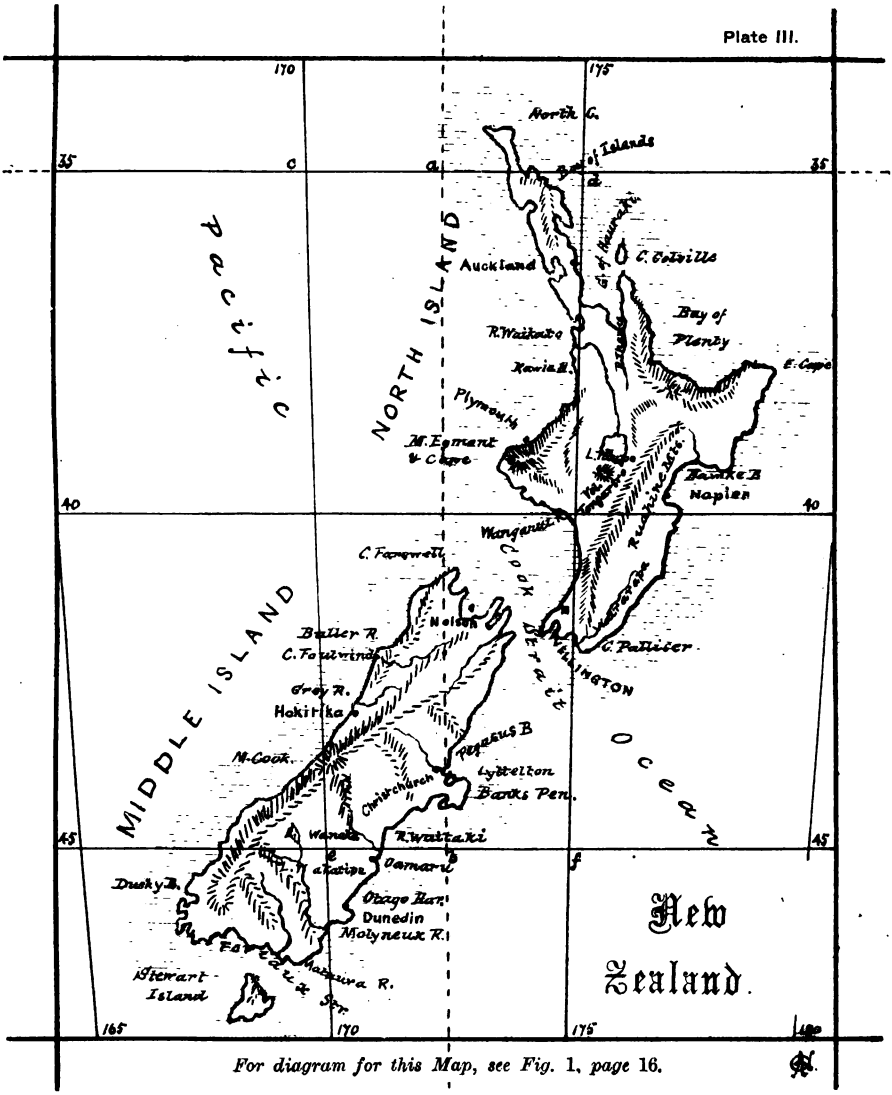


Fig. 3.

Plate III.



For diagram for this Map, see Fig. 1, page 16.

26.—Curved Parallels.—When it is required to draw curved parallels, as in the projection of Europe (Plate IV.), proceed as follows :—Draw a base line *a b*, and at its centre erect a perpendicular *c d*, *considerably longer than is required for the map*, for the central meridian of 20° E. As Europe is included between 35° and 75° N. lat., set off the equal distances from *i* to *q*, for the parallels of 35°, 40°, 45°, 50°, 55°, 60°, 65°, 70°, and 75° N. Draw parallel lines through *k* and *q in pencil*. Find the length of a meridian on the parallels of 45° and 75° by Fig. 1 (same Plate), and set off the distance A *x* to *g* and *h* on each side of *k*, and A *y* to *e* and *f* on each side of *q*. Join *g e* or *h f*, producing either line till it meets *d c* in *c*. The point *c* is the centre from which the parallels are to be drawn, by compass, through all the points *i* to *p*. Set off the meridian distance A *x*, already found by Fig. 1, on the parallel of 45°, to *r* and *s*. Join each point to *c*, and complete the projection as usual.

27.—It must be remembered that *the point c does not represent the North Pole.* It is the apex of the cone (paragraph 6), which is supposed to envelope the sphere, touching it at about the 55th parallel, the middle of the area represented in this map. In this case *c* is about 4° north of the pole. This method is the Conical Projection applied to represent a large area.

MERCATOR'S PROJECTION.[9]

28.—Mercator's Projection is more difficult to construct accurately than the preceding. The whole surface of the sphere[10] is "developed," or spread out on a plane, so that meridians and parallels are all straight lines; the meridians being parallel to each other at equal distances, and at right angles to the Equator.[11] The parallels, also "straight lines," are "placed at distances from the Equator, which increase in proportion as the spaces comprised between the meridians actually diminish upon the sphere," so that "at all places the degrees of latitude and longitude have to each other the same ratio as on the sphere itself." Tables to show this increase have been calculated by Trigonometry; they are called *Tables of Meridional Parts*, or *Tables of Increasing Latitudes*. By means of them the "increasing distances" mentioned above can be laid down on paper.

29.—To apply these tables, it is necessary to have a knowledge of the construction and uses of "Diagonal Scales," which though simple, requires much explanation, and, for the projection of any but large maps, is quite unnecessary. A separate scale has to be made for every map, and great care has to be taken in their construction. The table given below is calculated from the ordinary "Tables of Meridional Parts," to the *nearest* fraction which can be easily measured. As the amount of error is also given, due allowance can be made when constructing a large map. As, however, this projection cannot be constructed without using a table, it is not easily available for examination purposes.

30.—This projection is chiefly used for *Maps of the World* and *Sailors' Charts*, because, (1) The whole of the earth's surface can be represented in one map. (2) A straight course is always represented by a straight line, in any latitude, therefore a sailor can lay down his course without any calculation. Countries N. and S. are out of proportion to those near the Equator; they keep their *shape*, but are much too big, (*e.g.* Greenland, 1,400 miles long, looks as large as S. America, 4,000 miles), hence exact distances cannot be measured easily, but relative positions are correctly shown.

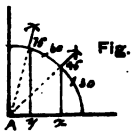
---

9 Invented in 1566 by a Fleming named Gerard Kaufman. (*Kaufman* is the German for *merchant*, and in accordance with a custom very common at this time, he changed his name into "the same name in Latin—viz., *mercator*=merchant.") He never explained the construction of this projection, but an Englishman, Edward White, discovered it in 1599.

10 In projection the earth is always spoken of as a sphere.

11 For the *theory* of this projection see "Groves' Primer of Geography," pp. 22-24.—*Macmillan*

Plate IV.



31.—Table of Increasing Latitudes, N. or S. from the Equator, the distance (*xy*) between any two meridians on the Equator being 1. The distances are so near that, except in large maps, little notice need be taken of the errors.

Degree.	Length.	Error.	Degree.	Length.	Error.
10°	= one time *xy*	$\frac{1}{200}$ of *xy* too small	60°	= $7\frac{1}{2}$ times *xy*	$\frac{1}{22}$ of *xy* too small
20°	= $2\frac{1}{24}$ times *xy*	exact, omit $\frac{1}{24}$	*or*	= $7\frac{8}{15}$,,	$\frac{1}{100}$,, ,,
23°28′*	= $2\frac{5}{12}$,, *xy*	$\frac{1}{600}$ of *xy* too large	66°32′†	= 9 ,,	$\frac{1}{200}$,, ,,
or	= $2\frac{1}{2}$,, *xy*	$\frac{1}{12}$,, ,,			
30°	= $3\frac{1}{7}$,, *xy*	$\frac{2}{75}$,, ,,	70°	= 10 ,,	$\frac{3}{20}$,, too large
40°	= $4\frac{1}{3}$,, *xy*	$\frac{1}{24}$,, too small	80°	= 14 ,,	$\frac{1}{24}$,, ,,
50°	= $5\frac{4}{5}$,, *xy*	$\frac{1}{100}$,, too large	90°	infinite.	

* Tropics of Cancer and Capricorn. † Arctic and Antarctic Circles.

32.—To Draw the Meridians (Plate V.)—Draw any line *ab* for the Equator, and a centre line *cd* at right angles to it, to represent the meridian of Greenwich. Take any distance, according to the size of the map required, to represent 10°, and set it off 18 times on each side of *cd*. This will now represent the 360, (10° X 18° + 10° X 18, or 180° + 180°), into which the Equator is divided. It is usual to draw two meridians more than this on one or both sides of *c d*, so that a complete representation of the earth may be taken in at one view.

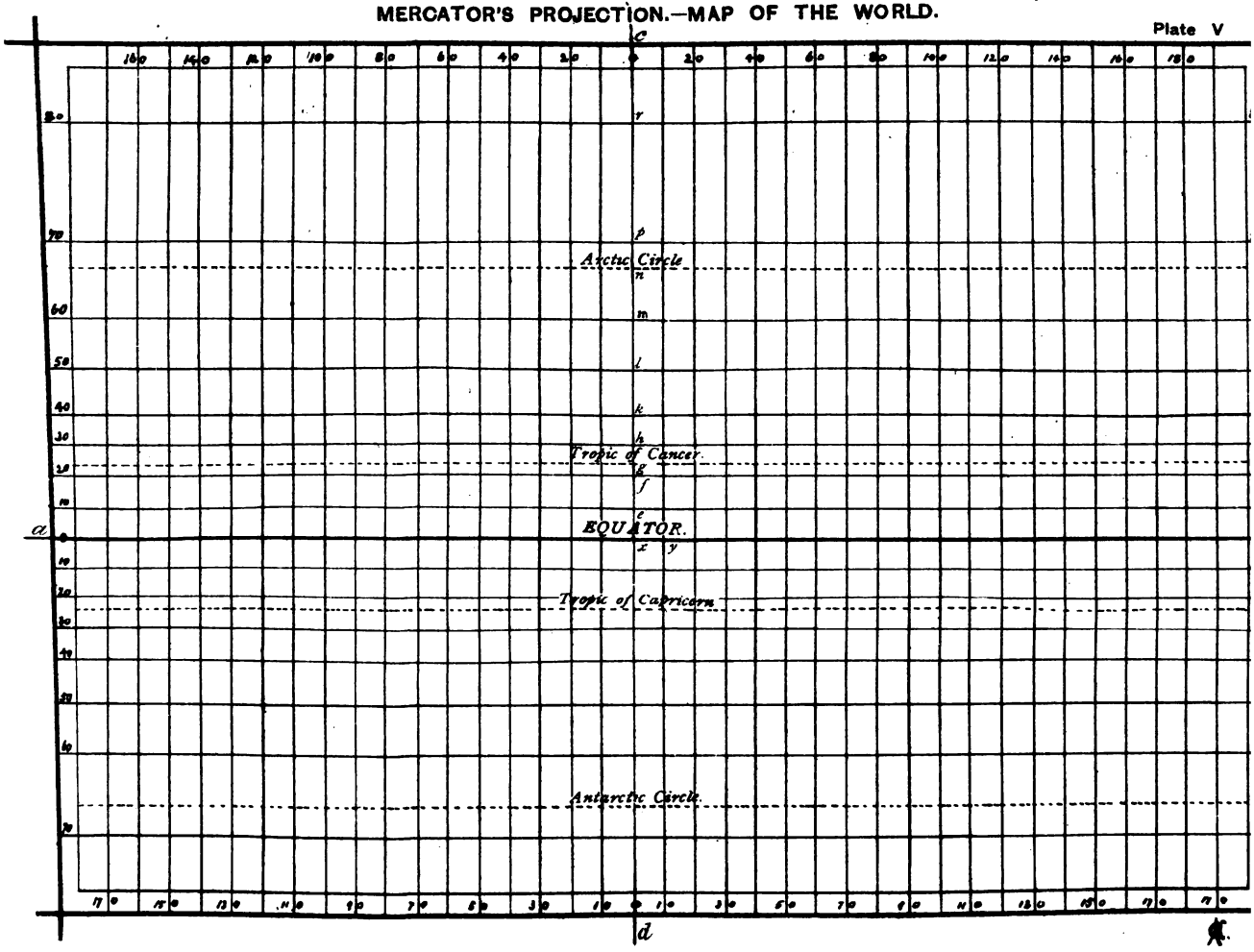
33.—To Draw the Parallels.—Use the Table, and measure all distances from the Equator, and on both sides of it. Calling the distance *xy* between any two meridians 1, the parallel of 10° N. or S. from the Equator will, according to the Table, be the same distance as *xy*, accurate within 1-200th part of *xy*. This is so small an error that no notice need be taken of it, except in very large maps. Set off, therefore, on *cd* with compasses from *x*, both N. and S. of *ab*, the distance *xe*, the same as *xy*. The parallel of 20° will be 2 and 1-24th times *xy*, but the 1-24th may almost always be neglected, as the fraction is so small. Set off again from *x*, both N. and S. of *ab* the distance *xf*—a very trifle more than twice *xy*. The Tropics of Cancer and Capricorn will be situated at the distance *xg*, on opposite sides of *ab*, or $2\frac{1}{2}$ times *xy*. In a large map this distance will be more accurate if it is made 2 and 5-12ths times *xy*. The parallel of 30° will pass through the point *h*, the distance *xh* being 3 and 1-7th times *xy*. The parallel of 40° will pass through the point *k*, the distance *xk*, being 4 and 1-3rd times *xy*. The parallel of 50° will be at the distance *xl*, or 5 and 4-5ths times *xy*. That of 60° degrees will be at the distance *xm*, or $7\frac{1}{2}$ times *xy*. If a large map is being projected, make this distance 7 and 8-15ths of *xy*. The Arctic and Antarctic Circles will be situated on opposite sides of *ab* at the distance *xn*, which is 9 times *xy*. The parallels of 70° and 80° will be situated at the distances *xp* and *xr*, which are respectively 10 times *xy* and 14 times *xy*. The projection cannot be carried nearer the Poles, and it is not necessary to go beyond 70° S. of the Equator. Draw lines parallel to *ab* through the points found, and complete by drawing the boundary lines and numbering.

If *xy* be some fractional part of an inch, as ⅓, ½, ¾, &c., and a plane scale be used which has the inch divided and sub-divided into 16ths, 12ths, 10ths, 8ths, &c., all the above fractions can be measured with sufficient accuracy for any ordinary purpose. Thus if the meridians are ½ an inch apart (this will give a map about 18in. by 12in.), 10° N. and S. of the Equator will be ½ an inch from *x*; 20° will be 1 and 1-48th, or a little more than 1 inch from *x*; 30° will be 1 and 8-14th in., or a little more than 1½ in. from *x*; 40°= 2 and 1-6th in. from *x*; 50°= 2 and 9-10th in., or nearly 8 in. from *x*; 60° = 3⅜ in. from *x*; 70°= 5 in. from *x*; and 80° = 7 in. from *x*.

34.—It is not of course necessary to draw *all* the parallels and meridians. Both parallels and meridians may be 20° apart In this case divide the distances given in the Table by 2; thus 20°=1; 30°=1 and 8-14ths (a little more than 1½); 40°=2 and 1-6th; 50°=2 and 9-10ths, &c. It is, however, far better to find the distances for *all* the parallels, but only to draw those required. In small maps it is usual to draw the meridians 20° or 30° apart, but to put in all the parallels. Sometimes the parallels of 20°, 40°, 60°, 70°, and 80° only are inserted.

MERCATOR'S PROJECTION.—MAP OF THE WORLD.

Plate V



GLOBULAR PROJECTION.[12]

.—There are three methods used by geographers to represent the world, in two portions, or hemispheres—viz., the or-'thŏ-'-ic, the stĕ-re-o-graph'-ic and glŏb'-ŭlar projection,[13] all of which are "perspective representations of the earth as it . appear to an eye placed in certain positions with regard to its surface." The Conical Projection (par. 27), and Mercator's ction (par. 28) are *developments* of the surface of the sphere.

.—**The Globular Projection** is the simplest of these to construct, and is the one which is almost always used in es to represent the World in Hemispheres. "The meridians are all the same distance apart, and so are the parallels when ured along the central meridian; but as they get nearer the outside of the map you will observe (Plate VII.) that the els become wider apart, and therefore the map is distorted at the edges, and the countries have not the same shape as ave on the globe." The *relative* dimensions of the countries nearly correspond to those on the globe, hence it is some- called the ĕ-quĭ-dis'-tant projection; but it does not represent figures *similar* to those on the globe, hence it *distorts the* of the countries.

.—To form this projection first describe a circle N.E.S.W., Fig. 1, Plate VI. (Two circles are required, joining at either W., as in Plate VII., for a complete map of the world; but only *one* of them is shown on Plate VI., so as not to crowd awing too much). Draw two diameters W.E. and N.S. at right angles to each other: N. and S. will represent the north outh poles; N.C.S. the central meridian, and W.E. the equator. Divide each of the quadrants W.N., N.E., E.S., and S.W. equal parts (by Fig. 2, Plate II.), numbering them 10, 20, &c., from the equator towards each pole. Divide each of the adii W.C., N.C., E.C., and S.C. also into 9 equal parts (by Fig. 3 or 4, see below* †).

.—**To Draw the Parallels.**—Produce N.C.S. indefinitely towards x and z, and draw arcs of inches through the points 10, a10, 10 (by Fig. 4, see below §) 20, b20, 20; 30, c30, 30; 40, d40, 40; 50, e50, 50, &c. The centres for these s will all be found in the line Nx (for the parallels of 10° and 20°, Nx will have to be produced a great distance beyond the . The method of doing this is shown for the parallels of 30°, 50° and 70° N., which are at 30y, 50y, and 70y respectively. liagram would be quite indistinct if all the centres had been found. Proceed similarly for parallels south of the equator.

Having found any centre on Nx, the centre for the same parallel south of the equator will be at the same distance from S, on Nz., as it is on Nx, from N.

.—**To Draw the Meridians.**—Produce W.C E. indefinitely towards p and r, and draw arcs of circles through the points S., 10, N; S., 0, N.; S., 20, N, &c. (by Fig. 4 see below §). The centres for these circles will all be found in the line E., r. The method of doing this is shown for the meridians of 10° E, 20° W, and 100° W.

In preparing a complete projection, as in Plate VII., it is best to find all the centres first on a separate diagram, *in pencil*, and then transfer them carefully with compasses. This keeps the finished projection clean, and prevents its being spoilt with the many holes made by the compass points

---

[13] Invented by Philippe de la Hire, a celebrated French mathematician *b* 1640, *d*. 1718.
For a brief description of the theory of this projection see "Groves' Primer of Geography," pp. 20-22.—*Macmillan.*

GEOMETRICAL PROBLEMS.

* To Divide a given Straight Line (as A B, Fig. 2, Plate VI.), into any number of Equal Parts (In this case 9).—From A draw a line as any angle. Set off 9 equal spaces on it from A towards C with compasses. Join 9 B, and through the points 8, 7, 6, &c., draw lines parallel to ting A B. These lines divide A B equally into the required number of parts. (The lines are easiest drawn parallel with a set square and straight edge.)
† Another Method (Fig. 3).—From A with any radius, as A B, draw arc B c, and from B with same radius draw arc A b. Take any distance on B c, and from A with same distance cut arc A b in b. Draw lines A 9 and B 9 through the points found, and set off on these lines from A and B ively 9 equal spaces. Join 9, 8; 8, 1; 7, 2; &c. These lines will divide A B into the required number of parts.
‡ To Describe a Circle, or an Arc of a Circle, passing through Three given points, as a b d, Fig. 4, Plate VI., which are not in the Straight Line.—Join a b, b d. From a and b with any radius more than half the line a b, describe arcs cutting in e and f; similarly from b and ribe arcs in g and h. Join the points ef and gh producing the lines till they cut in c. This point is the centre of the circle required.

GEOMETRICAL DIAGRAMS.

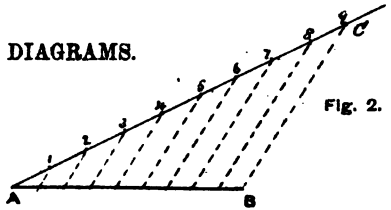


Fig. 2.

Fig. 1.

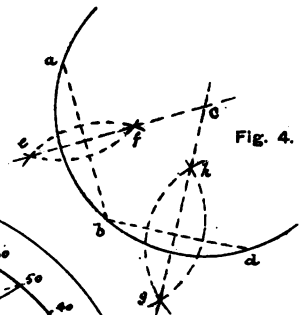


Fig. 4.

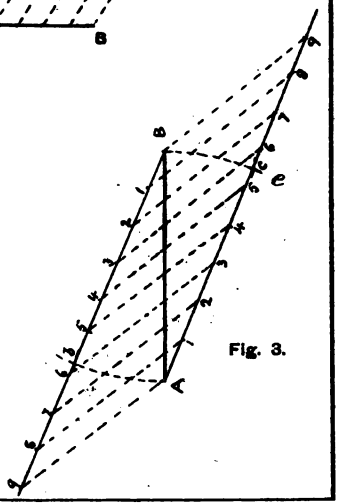


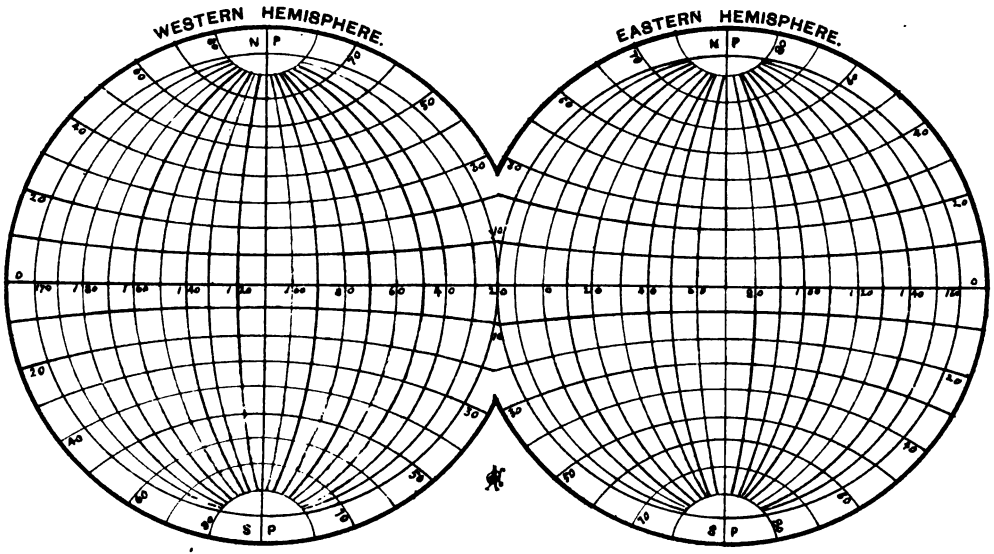
Fig. 3.

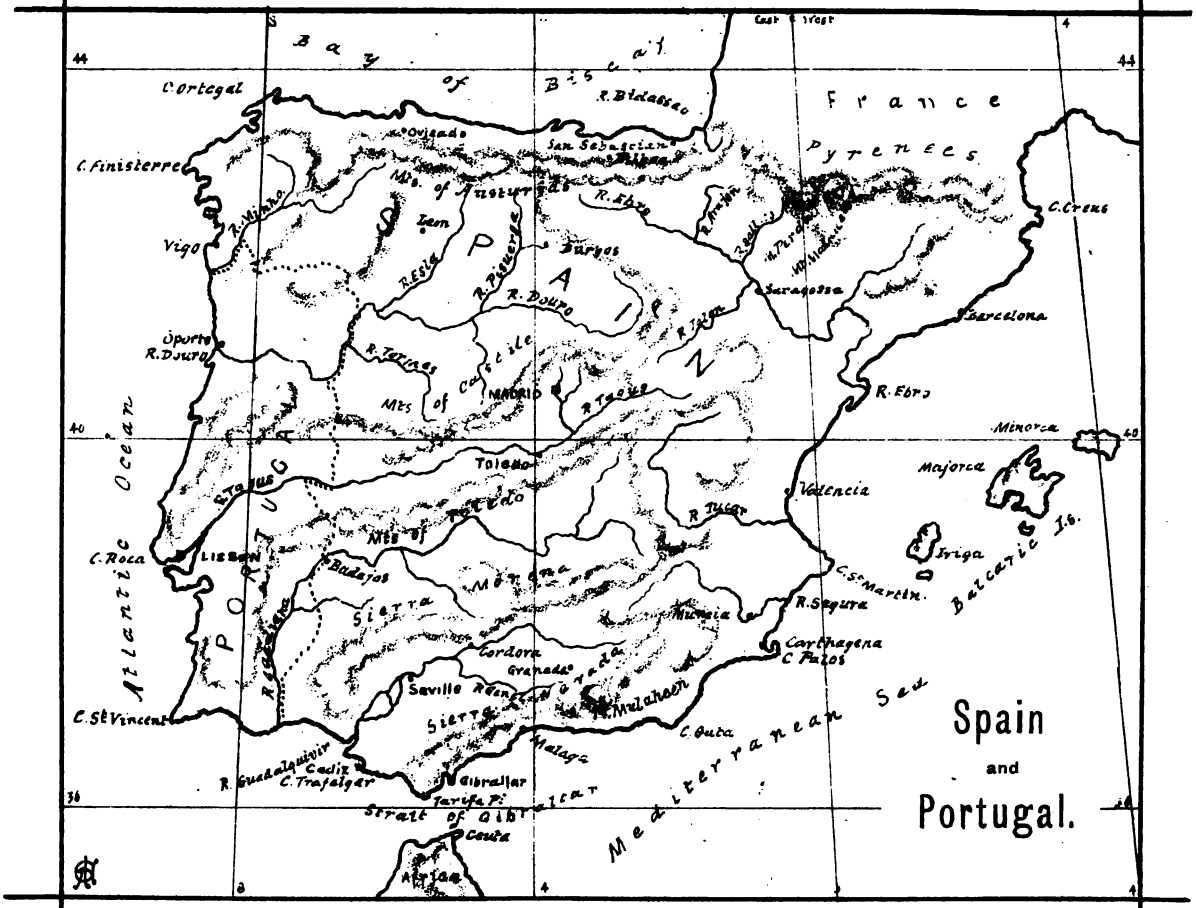
GLOBULAR PROJECTION

OF

THE WORLD.

Plate VII.





For diagram for this Map, see Fig. 2. page 16.

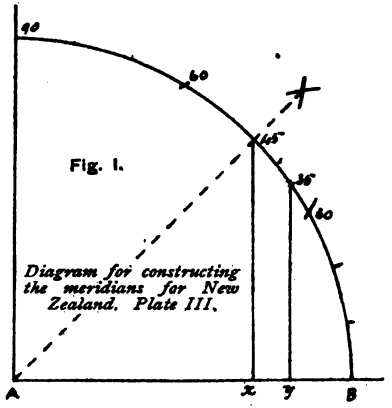


Fig. 1.

Diagram for constructing the meridians for New Zealand. Plate III.

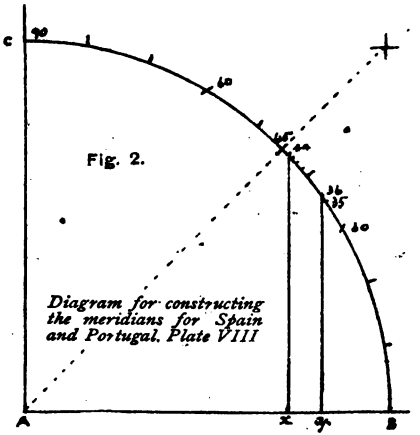


Fig. 2.

Diagram for constructing the meridians for Spain and Portugal. Plate VIII

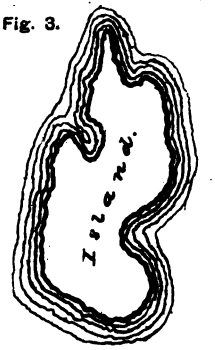


Fig. 3.

This style of coast shading is not recommended.

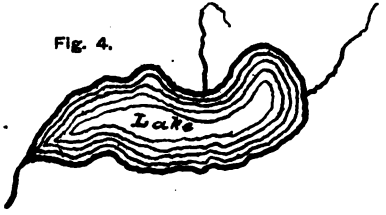


Fig. 4.

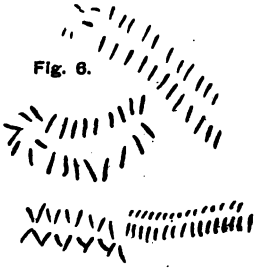


Fig. 6.

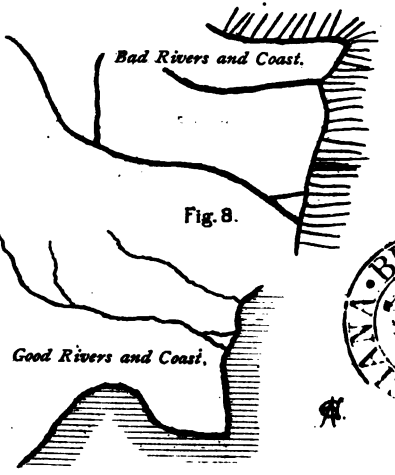


Fig. 8.

Fig. 5.

Fig. 7.